

P U B L I C A T I O N 1 7 3

SOYBEAN PRODUCTION



Ministry of
Agriculture
and Food

ONTARIO

Jack Riddell, Minister

R. A. Upfold, Crop Science Department,
University of Guelph

H. T. Olechowski, Plant Industry Branch,
Ontario Ministry of Agriculture and Food

CONTENTS

Introduction	2
Climate and Soil	2
Growth and Development	3
Choosing a Variety	4
Tillage and Seedbed Preparation	4
Inoculation	5
Planting	5
Reduced Stands	6
Fertility	7
Weed Control	9
Diseases	9
Insects and Mites	12
Other Problems	14
Harvesting and Storage	15
Feeding Soybeans	16
Marketing	16
References	Inside Back Cover

INTRODUCTION

The soybean, originated in China, where it was domesticated at least by the 11th Century, B.C. Its earliest documented cultivation in the western hemisphere was in the colony of North Carolina, before the American Revolution. It wasn't until 1893 that soybeans were introduced into Ontario as a hay crop.

The combination of an oil shortage during World War II and improvements in oil extraction and refining changed soybeans from a forage crop to an oilseed. From 1945 to 1987 soybeans have gone from 18,000 to over 450,000 hectares (ha) in Ontario. During this time average yield has more than doubled to 2.8 t/ha.

Soybeans contain approximately 40% protein and 20% oil on a dry matter basis. Although the oil is used primarily in edible products such as margarine and cooking oil, it is used industrially in such products as high-grade paints and pharmaceuticals. The soybean oil meal that remains after the oil is extracted is almost all used as a high protein livestock feed but the meal can be further refined to give various protein extracts for direct human consumption. To meet domestic demands alone, Ontario needs about 500,000 hectares.

CLIMATE AND SOIL

Temperature is the main climatic factor determining where soybeans can be grown in Ontario. Soybean varieties are rated by the amount of heat required to bring the crop to maturity according to the Ontario corn heat unit system. Figure 1 indicates the number of heat units available for growing soybeans throughout Ontario. At present there are recommended varieties that will mature in areas with 2400 heat units or more. More information on the Ontario corn heat unit system can be found in the OMAF Factsheet, *Heat Units for Corn in Southern Ontario*, Agdex 111/31.

Soybeans can be produced on a broad range of well-drained soil types. Medium-textured (loam) soils are ideal for soybean production. Heavy clay soils can lead to difficulties in planting and emergence, but once emerged, soybeans are well adapted. Sandy or gravelly soils, which tend to be droughty during the growing season, are least suited to soybean production.

A pH of 6.0 or above is recommended for soybean fields. Acid soils should be limed to at least this pH to produce high yields and allow good nitrogen fixation.

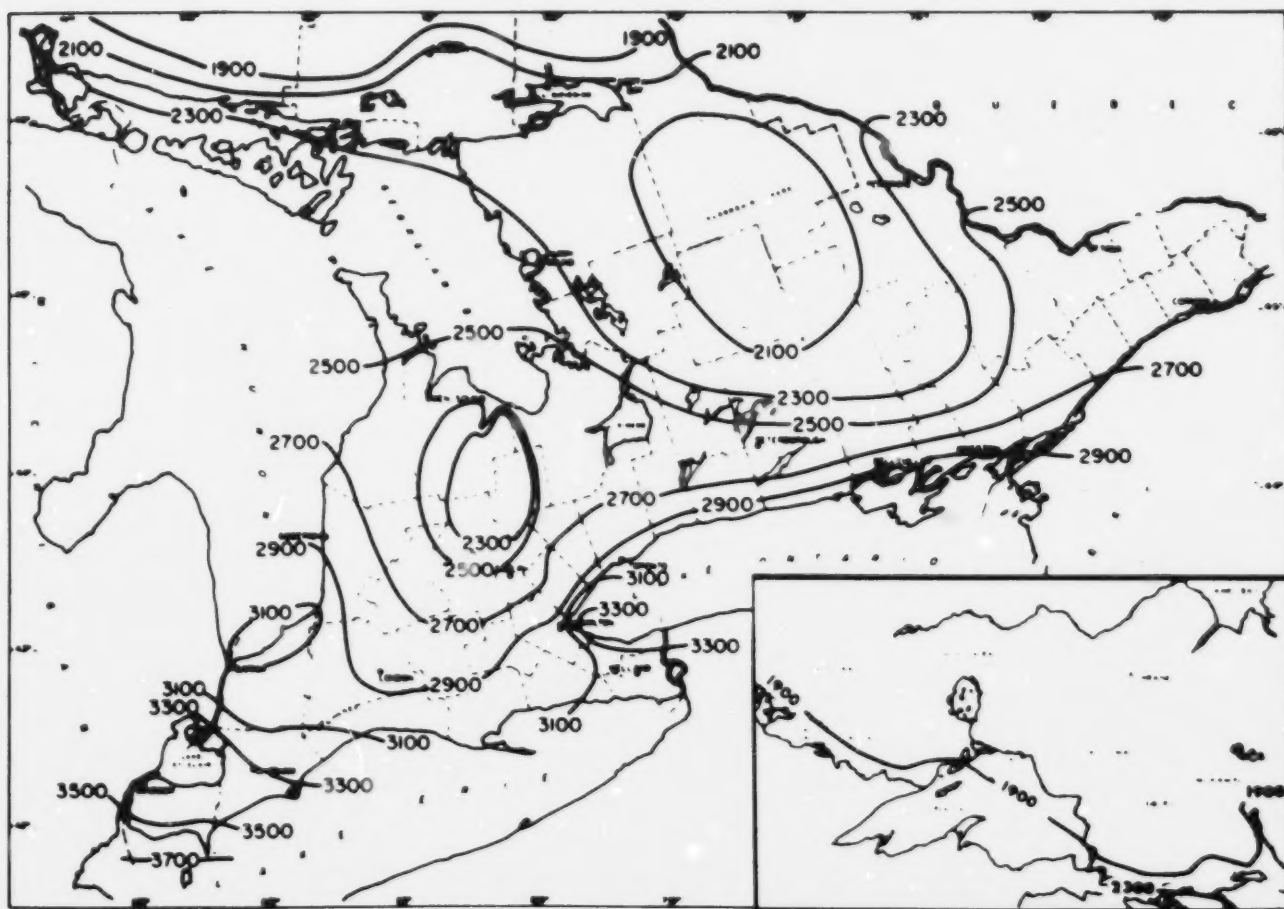


Figure 1. Heat Units Available for Soybean Production

GROWTH AND DEVELOPMENT

Germination and Seedling Development

Germination begins with the seed absorbing soil moisture until it is about 50% moisture content. The first external sign of germination is the emergence of the radicle (primary root) which grows downward and anchors itself in the soil. Shortly afterwards, the hypocotyl (section of the stem above the radicle) starts growing upwards pulling the cotyledons (seed leaves) with it. Once out of the soil, the hook-shaped hypocotyl straightens out, the cotyledons fold down and the growing point is exposed to sunlight.

Emergence normally occurs about 4 to 14 days after planting, depending on soil moisture, soil temperature and planting depth.

Flower, Pod and Seed Development

Flowering is triggered mainly by daylength and temperature. Very early maturity soybeans are nearly insensitive to daylength and flowering is controlled mainly by accumulated heat units. With later maturing varieties daylength becomes more important — the number of heat units required from emergence to flowering decreases as daylength shortens in July. This is one reason why late planted soybeans take fewer days to mature than earlier planted ones.

When planted at the normal time, soybeans will develop 5-8 leaves before flowering begins. All commercial varieties are indeterminate — plants develop new leaves and continue growing after flowering has commenced on the lower nodes.

Because soybeans are indeterminate, a plant will have some pods with developing seeds while flowers are still being pro-

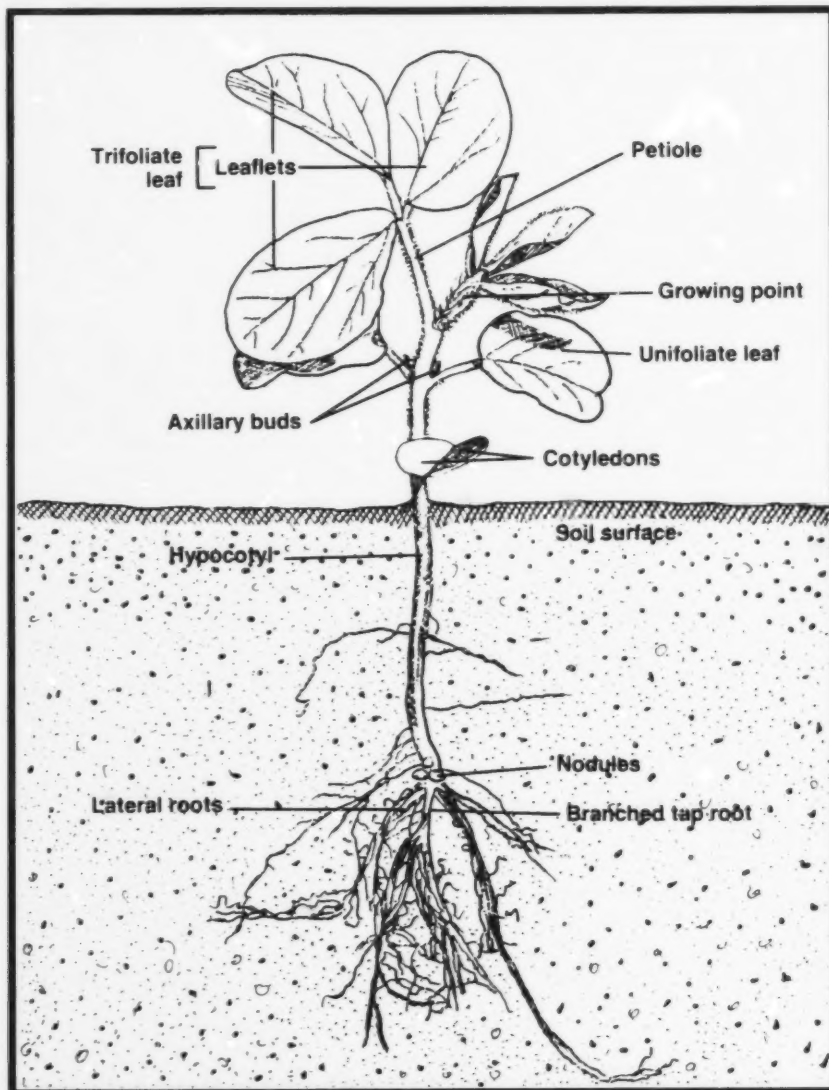


Figure 2.
Soybean seedling

Vegetative Development

The first two leaves are two unifoliate (single leaflets) occurring opposite each other at the first node above the cotyledons. Subsequent leaves are trifoliate (three leaflets) and on alternate sides along the stem. Normally those leaves formed first and last along the stem are smallest. When the plant has 2-3 trifoliate leaves, the nodules, important in nitrogen fixation, should be visible on the roots.

duced. In a normal year, it is estimated that 50 to 80% of the flowers fail to produce pods and as many as 50% of the pods may fail to develop seeds.

Beans within a pod will not start growing until the pod has reached its full length. The seed filling period is very critical in determining final yield. Drought during this period could affect seed maturity, seed size, number of seeds per pod and number of pods.

In the fall, as the plant matures, the leaves die from the bottom of the plant up. With this decline in photosynthesis and the reduction in nitrogen fixation, the seed continues to grow by moving nutrients from other plant parts. Seeds reach their maximum dry weight and are physiologically mature when their moisture content is 42 to 45%. After physiological maturity it is just a matter of drying down to allow harvesting.

CHOOSING A VARIETY

One of the most critical decisions in growing soybeans is variety selection. Each year, results from performance trials conducted across the Province are published in both Publication 296, *Field Crop Recommendations* and the *Ontario Soybean Variety Trials Report*. In these reports, varieties are assigned a heat unit rating and characteristics such as yield, lodging and disease resistance are given.

It is important to select a variety that corresponds to the heat unit rating for your farm (Figure 1). A variety that takes advantage of the full growing season will generally yield more than those maturing earlier. One should consider varieties earlier than full-season if winter wheat is to follow the soybeans.

Lodging is often a problem on very fertile soils and/or soils with a high moisture availability. If lodging has been a problem then choose a variety that has a low lodging rating.

Because of the large effect growing conditions have on yield and lodging it is important to use data that has been collected over a wide range of environments and not just one location for one year. The results given in the variety trials are averages, from a number of locations and years.

On the heavy clay soils of southwestern Ontario, phytophthora root rot is a potential problem. Varieties with resistance or tolerance to phytophthora root rot are available. There is a difference between a tolerant and a resistant variety.

1. **Resistant Varieties.** The Phytophthora fungus is present in Ontario soils as a series of races (or "strains"). Resistance protects a variety against some, but not necessarily all the races. If a variety's resistance corresponds to the particular races in a field, the disease will be controlled. However, if the variety's resistance does not match the race present, possibly because the race has changed, the crop may be infected.
2. **Tolerant varieties** show some disease symptoms when grown in infested soils regardless of which races of the disease are present. However, yields of these varieties are not seriously reduced by the disease. In both Publication 296, *Field Crop Recommendations* and the *Ontario Soybean Variety Trials Report*, tolerant varieties are those varieties without multi-race resistance but still having low values for percent plant loss.

TILLAGE AND SEEDBED PREPARATION

Tillage

Tillage is used to manage previous crop residues, reduce disease problems, incorporate fertilizer and lime, provide some weed control and most importantly prepare a satisfactory seedbed.

The ideal seedbed provides a place for seeds to germinate quickly and for seedling roots to obtain moisture and nutrients. A seedbed should have good surface tilth that will prevent crust formation and allow rapid, even emergence. The tillage required to make a seedbed will vary depending on the soil type and the amount of crop residue. Using only that tillage which is necessary to produce a firm seedbed will reduce soil compaction, time, and labor.

Application of large amounts of fertilizer and lime are best done by broadcasting and incorporating them in succeeding tillage operations. Since the late 1950's chemical herbicides have reduced the need for tillage in a weed control program. However, some chemicals need to be incorporated into the soil and some weed escapes may need to be controlled by inter-row cultivation. (See Publication 75, *Guide to Weed Control*.)

In recent years conservation tillage systems have become more popular. With the improvement of planting equipment there is no need to bury all of the previous crop's residues. A tillage system that will leave 20% surface residue cover at planting and mix the remaining residues evenly throughout the soil profile will qualify as a "Conservation Tillage" system, reduce water erosion, and improve soil tilth.

With the advent of new soybean herbicides and better planting equipment, many growers have been able to produce good crops in minimum or no-till systems. Reducing tillage does not normally affect soybean yields.

Farmers should consider these points when evaluating a tillage system change:

- (a) What will be improved by a change in the tillage system?
- (b) Will the change in the tillage system fit into current or future cropping programs?
- (c) How will you change? Do you need new skills, or a large cash investment in new machinery?
- (d) When will you change? This is perhaps the most critical decision. Changes made when replacing worn out equipment result in the least economic stress.

Considering the above factors, farmers can make their decision as to the best tillage system or set of systems for their own farming operation.



Figure 3. A uniform stand of soybeans in a no-till system following a cover crop.



Figure 4. A no-till planter. Note the fluted coulter ahead of the planter shoe to allow uniform planting depth.

Rotation

Soybeans should not be grown in the same field for more than 2 years in a row because of potential disease problems. In particular, root rots such as phytophthora and rhizoctonia tend to increase in severity in a soybean monoculture. Soybeans should not follow edible beans, canola, or sunflowers in the rotation, as diseases like white mold can carry over and reduce soybean yields. Wheat, spring grains and corn are the preferred crops for rotation with soybeans.

INOCULATION

When soybeans are grown on land for the first time, inoculation with soybean rhizobia is essential for high yields. Under these conditions, soil-applied granular inoculants produce more consistent nodulation and higher yields than seed-applied powders. Therefore, granular inoculant is recommended on new soybean land, at rates from 5 kg/ha in wide rows up to 10 kg/ha in rows 18 cm apart.

Granular inoculant is applied through granular insecticide applicators on a corn planter, with delivery tubes brought forward to place the inoculant in the seed furrow. In a grain drill, the grass seed box can be used for granular inoculant with tubing added to drop the inoculant with the seed. With newer drills, the granular inoculant may be applied through the fertilizer hopper. After nodulated soybeans have been grown on a field, the use of granular inoculant is not recommended because it usually does not cause yield increases.

If soybeans have only been grown for one or two years, or if they have not been grown for several years, soybean seed should be inoculated with powdered peat inoculant to ensure nodulation. For growers using powdered inoculant, use of a sticker will ensure uniform adhesion to the seed.

As a remedial measure, if nodulation does not occur, apply 50 kg/ha of nitrogen at first-flower.

When an adequate population of soybean rhizobia has been established in field, it will remain for many years and further inoculation is not necessary.

PLANTING

Seeding Rate

The seeding rate of soybeans is not as critical as the seeding rate of corn. Soybeans can compensate for differences in plant stands without affecting yield. However, too high a seeding rate adds unnecessary seed costs and may increase

lodging. Too low a seeding rate may result in poor emergence and uneven stands, especially if crusting becomes a problem. Low plant populations and uneven stands usually increase harvest losses because more pods develop closer to the soil on widely spaced plants. Seeding rates as listed in Table 1 will provide satisfactory stands if 90% of the seeds emerge. Approximately 70 kg/ha (60 lb/ac) of seed are recommended for row widths of 35 to 71 cm (14 to 30 in.). For row widths less than 36 cm (14 in.), 100 kg/ha (90 lb/ac) of seed are recommended (Table 1). The higher seeding rate in narrow rows will assist seedlings to emerge if crusting problems develop.

When determining seed requirements or calibrating planting equipment, make allowances for seed quality and seed size. The average number of seeds per kilogram for each variety is found in OMAF Publication 296, *Field Crop Recommendations* and the *Ontario Soybean Variety Trials Report*.

Planting Depth

The depth of planting has a very important influence on the uniformity of the emerged soybean stand. The ideal planting depth should be between 2.5 and 4 cm. Shallow planting is recommended when planting early into cold soils. Avoid planting too deep as some varieties may not emerge because they have short hypocotyls. Deep planting also results in longer exposure of the emerging seedling to soil-borne diseases. Under extremely dry conditions, it is better to plant shallow and wait for a rain rather than plant too deep into moisture.

New planters and drills have good control over planting depth. When planting with older grain drills check your planting depth carefully every time you plant in different soil conditions.

Planting Date

Soybeans begin germination when the soil temperature reaches 10°C. Because seeds planted early into cooler soils require longer to germinate and emerge they are more subject to infection from disease organisms. In most areas of southern Ontario, soil temperatures reach 10°C between May 10 and May 25. Highest soybean yields are generally obtained when soybeans are planted during this period.

Traditionally, soybeans have been planted later than corn for two reasons. First, there is a belief that soybeans are very sensitive to frost damage. A soybean plant, however, can withstand a temperature as low as -2.8°C (27°F) for a short period of time; a corn plant will suffer tissue damage at -1.7°C

Table 1. Seeding Rate

Number of Seeds/Kilogram	Row Width (centimetres)			
	18	36	53	71
	Number of Seeds/Metre of Row ¹			
	10	15	21	29
	Seeding Rate ² (kg/ha)			
4000-5000 (large seeds)	154-123 ³	115-92	115-92	115-92
5000-6000	123-103	92-77	92-77	97-77
6000-7000	103-87	77-67	77-67	77-67
7000-8000 (small seeds)	87-78	67-58	67-58	67-58

¹18 cm row width calculations based on a stand of 500,000 plants per hectare; 36 cm and wider row width calculations based on a stand of 400,000 plants per hectare.

²Calculations are adjusted for 90% seed germination.

³Kg/ha x .9 = lb/ac.

(29°F). Unlike corn, however, the growing point of the soybean plant is near the top of the plant, not insulated by soil, and therefore frost damage is usually permanent. This type of damage may occur with a late spring frost.

In most of Ontario, planting of soybeans and corn compete for equipment and time. Yields of corn decrease much more with a delayed planting date than do yields of soybeans. It makes sense to plant corn first and soybeans second.

There are several reasons you may decide to delay planting. If lodging is a problem, you can generally reduce plant height by delaying planting. If white mold has been a problem in the past, you can reduce its severity by reducing the density of the crop canopy with delayed planting (see *White Mold* under *Diseases*).

If winter wheat is to be grown after soybeans using conventional tillage methods, select a variety that requires about 300 heat units less than the number available in your area. If winter wheat is to be broadcast into a standing crop, select full-season varieties.

Late Planting

In southwestern Ontario plant full-season varieties until June 10-15th. After that date, select earlier varieties at about the rate of 100 heat units/week. In central and eastern Ontario follow the same guidelines except use earlier maturing varieties after about June 10th. Because delayed planting decreases plant height and bottom pod height, select taller varieties and plant in narrow rows.

Seed Treatment

Seed treated with an insecticide-fungicide combination survives poor germinating conditions better than untreated seed. Following wet harvest seasons when molds become a problem, a fungicide seed treatment may be necessary to insure acceptable seed germination.

Fungicide seed treatments control many of the seed-decay organisms. An insecticide treatment i.e., diazinon and lindane, helps control seed maggots and wireworms. When an insecticide is used, follow the recommendations on the manufacturer's label. The application of the insecticide alone (i.e., without a fungicide) may result in reduced germination and stunting after emergence.

Seed treatments can be detrimental to soybean inoculant that is being applied to the seed. Treat soybean seed just before planting. If the seed is not planted the same day as it was treated, inoculate a second time.

Seed Quality

Canada has an effective Seeds Act and inspectors of Agriculture Canada monitor seed quality. In addition, companies have seed quality control programs. Farmers should, therefore, encounter few problems with the germination level of pedigreed soybean seed. However, if emergence problems occur it may be necessary to check the quality of the seed involved. Tags on each bag of seed soybeans indicate the germination level, the date it was tested and the seedlot from which it was obtained. Unless these tags are saved it is impossible to re-check the quality of the seed if a problem arises. A set of tags from each seedlot along with a small sample of seed should be saved to assist in tracing the cause of problems.

Do not use carry-over soybean seed as germination is usually reduced to an unacceptable level. If home grown seed is to be used it would be wise to check the germination of seed before planting. One approach is to place 100 seeds between moist paper towels. The towels should be kept moist

(but no standing water) and at room temperature. At the end of a week, the number of seeds with healthy sprouts represents percent germination. A more reliable test involves planting the seed in a flat of soil. This test should be conducted at a lower temperature (12 to 15°C). A cool basement or back kitchen may be suitable. The number of healthy plants that emerge within two weeks represents percent emergence.

The interpretation of these tests is very difficult, and if there is any question of seed quality, tests should be done by an accredited seed testing laboratory. Planting rate should be increased to compensate for reduced emergence.

Germination and Vigor

Often the terms "germination" and "vigor" are used interchangeably. They do not have the same meaning. Percent germination tells you the percentage of seeds that produced a healthy plant in a warm germination test. "Vigor" refers to the ability of the seed to produce a healthy, uniform plant stand under a wide range of growing conditions. A seed lot may have a high germination percent but because of cracks in the seed coat or seed-borne diseases, emergence may not be adequate. Many companies are using several germination and vigor tests. The most common of these tests are: standard warm germination, accelerated aging, cold test, tetrazolium, and the automatic seed analyzer. Through careful testing and interpretation of the results, a high quality product is ensured.

Row Width

Highest yields are usually reached by growing the crop in narrow rows (or solid seeded). In practice, the choice of row width depends on several factors including equipment availability, weed problems, experience, soil conditions and planting date. The increase in yield potential from growing soybeans in narrow rows is greatest in the short season areas and decreases as you move towards southwestern Ontario. In Southwestern Ontario, there may be some advantage (Table 2) in reducing row widths to less than 50 cm (20 in.) while 18 cm (7 in.) rows are recommended in short season areas.

There is a yield advantage in solid seeding when planting is delayed into the month of June. The advantages of narrow rows decrease as weeds and crusting problems increase. Weed control problems must receive special consideration because narrow rows will prevent row cultivation.

Table 2. Effect of row width on yield

Decreasing Row width (cm)		Increase in yield (%)
Initial	Final	
71	53	7.3
71	36	12.8
71	18	15.4
53	36	5.5
53	18	8.1
36	18	2.6

(G. Ablett, RCAT, 1980-81)

REDUCED STANDS

A number of factors can cause reduced soybean stands. These include crusting, herbicide injury, frost, hail, insects and diseases. Of these factors, soil crusting, herbicide injury and diseases most frequently cause problems.

Crusting

A hard soil crust may form when a heavy rain falls on fine textured soils. Occasionally the emerging plant is unable to break through the crust. When this happens, the seedlings may deplete the food stored in the cotyledons before emergence. The most severe damage resulting from a soil crust will be the actual breaking of the young seedling as it tries to push its way to the surface. Rotary hoeing or harrowing to break the crust will help emergence (Figures 5 and 6).

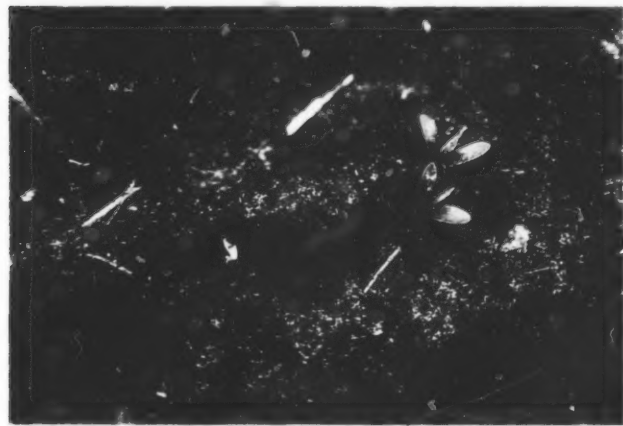


Figure 5. Severe soil crusting results in reduced emergence.



Figure 6. Effective use of a rotary hoe can break up a crust and control small weed seedlings.

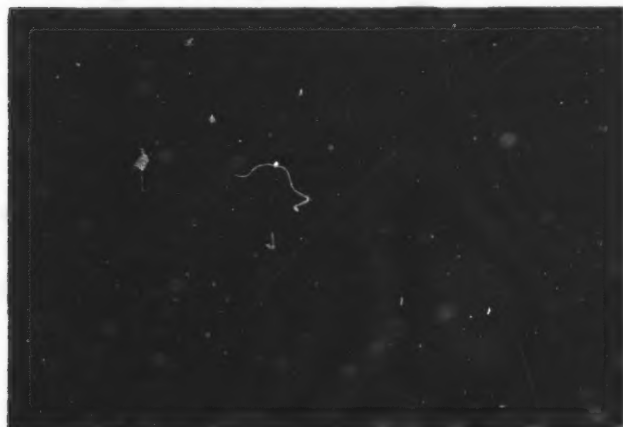


Figure 7. Herbicide residue damage.

Herbicides

Herbicide injury symptoms are frequently encountered shortly after planting. They include a progressive yellowing and eventual browning or scorching of the leaves, swollen stems, and thickened secondary roots (Figure 7).

The soybean plant has a tremendous capacity to recover from herbicide damage. If the upper stem and leaves are destroyed, buds lower down the stem are stimulated to form new leaves and branches and the plant recovers. Destruction of the seedling below the cotyledon kills it, thereby reducing the stand since there are no buds below the cotyledons.

Herbicide damage is usually caused by residues, excessive application rates, using the wrong chemical, uneven application, improper calibration or poor incorporation.

Diseases

Under certain conditions soil and seed-borne diseases can reduce emergence. The most common diseases are phomopsis seed mold, phytophthora root rot and pythium rot (see *Diseases*). To reduce these disease problems, plant only high quality certified seed, treated with a recommended seed treatment as listed in the OMAF Publication 296, *Field Crop Recommendations*.

Replanting

The decision to replant is often the most difficult one a grower faces. Factors to consider are the cause of the poor stand, date of replanting, remaining population and weed control. Normal seeding rates contain a large margin of safety to ensure emergence of an adequate stand. Research in Ontario shows that 60% of a normal plant stand with healthy, vigorous plants will not significantly reduce yields under most circumstances. It would be unwise to plant thin stands of soybeans intentionally. Stands planted thinly, may be reduced even further at emergence by unfavorable conditions.

The decision to replant has to be made on an individual field basis, but a good rule of thumb is if there are 16 healthy, vigorous plants per m² (1.5 plants per sq. ft.) replanting will not usually result in higher economic return.

FERTILITY

Soybeans need a high level of fertility to produce top yields. A 3.4 t/ha crop of soybeans contains 134 kg of nitrogen, 27 kg of phosphate and 54 kg of potash as well as secondary and micronutrients. About 75% of the nitrogen and phosphate and about 60% of the potash is contained in the seed at harvest.

A common misconception is that soybeans respond only to residual fertilizer from the previous crop. Research has shown soybeans respond not only to residual fertilizer, as all crops do, but to applied fertilizer as well.

Soils vary considerably in their ability to supply nutrients, depending on soil type and past management. Since nutrients supplied by the soil are essentially free-of-charge (or have already been paid for), fertilizer application should take them into account. A soil test is the best way to determine fertilizer and lime requirements. A soil test should be taken at least once every two or three years.

NITROGEN

Soybeans contain a large amount of nitrogen in the form of protein. Fortunately, because soybeans are legumes and

fix their own nitrogen, large amounts of nitrogen should not be applied.

If you are banding phosphate and potash through a corn planter, the addition of 10 kg/ha of actual nitrogen may be beneficial. If you aren't applying phosphate and potash or are broadcasting it, there is no benefit to that small amount of nitrogen.

Occasionally, the nitrogen fixing activity of the nodules is not sufficient to meet the needs of the plant (Figure 8). When symptoms of a nitrogen deficiency appear (pale green to yellow leaf color), apply 50 kg/ha of actual nitrogen at first-flower.



Figure 8. Test plots comparing good inoculation to poor inoculation.

PHOSPHORUS

There are no specific symptoms for a phosphorus (phosphate) deficiency in soybeans. A soil test and tissue analysis are the only reliable fertilization guides (Table 3).

Phosphorus is taken up throughout the growing season and stored in the leaves and stem. It is then moved to the pods and seeds as they start developing.

Soybeans do not get the early growth stimulation from a small amount of phosphorus placed near the seed that is normally seen with corn.

POTASSIUM

Soybeans require relatively large amounts of potassium. The rate of uptake climbs to a peak during rapid vegetable

growth, then slows down as the beans start forming. At maturity, the beans contain about 60% of the potassium in the whole plant. This is in contrast to corn, where the seed contains only 25% of the potassium.

MANGANESE

Manganese is the most common micronutrient deficiency found in soybeans. Deficiencies can occur at pH values above 6.0 and on organic soils or mineral soils high in organic matter. Deficiency symptoms may also appear where plants are infected with root rots (see *Rhizoctonia* in *Disease Section*).

The upper leaves of a manganese deficient plant can range from pale green (slight deficiency) to almost white (severe deficiency) while the veins remain green (Figure 9). In addition to deficiency symptoms both soil tests and plant analyses (Table 3) are useful in predicting where manganese deficiencies are likely to occur.



Figure 9. Manganese deficiency symptoms appear as yellowing between the veins.

Correct the deficiency as soon as detected by spraying the foliage with 2 kg/ha of manganese from manganese sulfate (8 kg/ha) in 200 L of water. A "spreader-sticker" in the spray is recommended. If the deficiency is severe, a second spray may be necessary.

Soil application is not a recommended way to apply manganese because of the large amount required. Application of manganese chelates to the soil has resulted in yield reductions. For further details on manganese deficiency and on

Table 3. Nutrient Concentration in Soybean Leaves¹

Nutrient	Units	Critical Concentration ²	Maximum Normal Concentration ³
Nitrogen (N)	%	4.0	6.0
Phosphorus (P)	%	0.15	0.5
Potassium (K)	%	1.2	2.5
Calcium (Ca)	%	—	3.0
Magnesium (Mg)	%	0.1	1.0
Boron (B)	ppm	20	55
Copper (Cu)	ppm	4	30
Manganese (Mn)	ppm	14	100
Molybdenum (Mo)	ppm	0.5	5.0
Zinc (Zn)	ppm	12	80

¹Values apply to the top fully developed leaf (3 leaflets plus stem) at first flowering.

²Yield loss due to nutrient deficiency is expected with nutrient concentrations at or below the "critical" concentration.

³Maximum normal concentrations are more than adequate but do not necessarily cause toxicities.

methods of application, see OMAF Factsheet, *Manganese in Soybeans and Small Grain Production*, Agdex 100/531.

FERTILIZER APPLICATION

Soybeans are very susceptible to fertilizer "burn". Do not apply fertilizer with the seed. If a drill is being used, broadcast and work the fertilizer in, prior to planting. This can be done either in spring or fall.

With a corn planter, fertilizer can be banded 5 cm to the side, and 5 cm below the seed. The amount applied should not exceed 30 kg/ha of actual nitrogen or more than 90 kg/ha of actual nitrogen plus potash.

WEED CONTROL

Weed control is one of the most important factors in successful soybean production. Soybeans cannot compete with weeds in the early part of the growing season. Herbicides, or cultivation, or both, are often needed to control weeds until the soybeans have developed enough canopy to provide more competition. As soon as soybeans fill in the rows, weeds are suppressed.

Rotary Hoe and Row Cultivation

The soybean grower can use a rotary hoe, when soybeans are emerging, to break the soil crust and to destroy weed seedlings. The use of the rotary hoe can also improve the effectiveness of preemergent herbicides under dry soil conditions. The rotary hoe is most effective when operated at 12 to 16 km/h (8 to 10 mph) on warm, sunny days when the soybeans are slightly wilted to reduce the amount of damage to the soybeans. The rotary hoe can be used safely until the beans are 15 cm (6 in.) high. Up to this stage, soybeans are rooted more deeply than weeds, and although the soybeans may appear damaged, they recover rapidly. A 10% reduction in plant stand is common with each pass of the rotary hoe.

Row cultivation can be used in rows of 46 cm (18 in.) or more as a means of complete weed control, or to remove weeds that have escaped herbicide treatments. Cultivation does not control weeds in the row and it may damage the soybean root system after the beans are 20 to 25 cm (8 to 10 in.) high. Cultivation should be shallow so soil that is infested with weed seeds is not brought to the surface. It is difficult to control weeds in a large soybean acreage by cultivation alone because many of the fields require cultivation at the same time. Growing soybeans in narrow rows makes cultivation impossible and weed control must be obtained with herbicides.

Cost-effective weed control can be obtained by the band-application of herbicide over the row followed by cultivation.

Herbicides

Herbicides that can be applied preplant incorporated, pre-emergent, or post-emergent are available to control a wide range of annual grasses and broadleaf weeds in soybean fields. Perennial weeds, such as quack grass, Canada thistle, milkweed and field bindweed, should be controlled before planting soybeans.

Most herbicides are effective on either broadleaf weeds or grasses but seldom does one herbicide give satisfactory control of both. The best weed control is obtained by using a combination of two herbicides or by using a combination of herbicides and cultivation.

Rainfall influences the effectiveness of herbicides. Pre-emergent herbicides require adequate rainfall within one to two weeks of spraying to activate them. If rainfall does not occur until after this time period, these herbicides may be only partially effective.

When a herbicide is incorporated into the soil according to label instructions, weed control may be more effective because the herbicide is not as dependent on rainfall to activate it.

Since changes in weed control are on-going, it is important to obtain a copy of OMAF Publication 75, *Guide to Weed Control*, for the most up to date information.

Herbicide Damage

Soybeans are susceptible to atrazine residues. Do not grow soybeans following corn unless you are sure there are no harmful residues present. Generally, if less than 1.8 kg/ha (1.6 lb/ac) of atrazine was sprayed on corn for one year, soybeans can be grown the following year. If, however, corn has been grown for two years or more, and atrazine was used each year to control weeds, no more than 1.1 kg/ha (1 lb/ac) should be sprayed in the year previous to growing soybeans. If the weather is hot and dry, atrazine residue damage may occur especially where the sprayer overlapped.

Some soybean herbicides may cause damage to the crop when applied at rates too high for the soil type. Always read the herbicide label for proper rates. Heavy rains can cause the herbicide to splash-up onto the leaves or leach into the root zone. Usually this injury is temporary, the lower leaves may be burned, but generally the soybeans will recover with little effect on yield. If in doubt about crop injury, contact your crops specialist or herbicide supplier.

DISEASES

Although diseases can be a problem in soybeans, use of resistant or tolerant varieties, good management practices and recommended seed treatments, reduces the incidence of disease to the point where yield losses are generally small.

Damping-Off

Damping-off in soybeans is most prevalent on clay soils during cool, wet springs. Seedlings may fail to emerge or die shortly after emergence. Damping-off is caused by several fungi, including phytophthora root rot, rhizoctonia root rot, phomopsis seed mold, and pythium seedling rot. Control measures include using high quality seed, using a recommended seed treatment and planting into a firm, well drained seedbed. Any practice which will encourage rapid emergence will reduce the incidence of damping-off.

ROOT ROT DISEASES

Rhizoctonia Root Rot

This disease has been found in most of the soybean growing areas of southwestern Ontario. Symptoms of rhizoctonia are reddish lesions on the roots and lower stem (Figure 10), and a characteristic, reddish "banding" on the stem at or just above the soil line. Early infection can lead to damping-off, while later infections can lead to wilted plants under dry conditions as the roots die. Often leaves of infected plants show a manganese deficiency even in soils where there is adequate manganese. Following a rain, the plant outgrows this deficiency as new roots are produced.



Figure 10. Rhizoctonia root rot is characterized by lesions on the tap roots and the absence of secondary roots.

There are no varieties resistant to this disease. The use of a seed treatment will help reduce the damping-off caused by rhizoctonia. Improving drainage and soil tilth will reduce disease severity.

Fusarium Root Rot

This disease is very similar to rhizoctonia root rot in appearance and extent. Symptoms are reddish lesions on the roots but unlike rhizoctonia, there is no "banding" on the stem at the soil line. Very often these root rots are found together on one plant and are indistinguishable without laboratory testing. Control measures for fusarium root rot are the same as for rhizoctonia (see above).

Phytophthora Root Rot

Phytophthora root rot has caused major losses in soybeans grown on the clay and clay loam soils of southwestern Ontario. It has recently been identified on the clay soils of central Ontario as soybeans have expanded into that area.

This disease can infect plants anytime during the growing season. Early symptoms are collapsed seedlings with a "water soaked" lesion on the stem at the soil line. Later infections cause a characteristic wilting of the leaves which remain attached to the plant. The roots have dark brown lesions and a dark purple discoloration of the stem extending to the upper nodes is common. There may be single diseased plants (Figure 11), but more commonly they are found in patches.

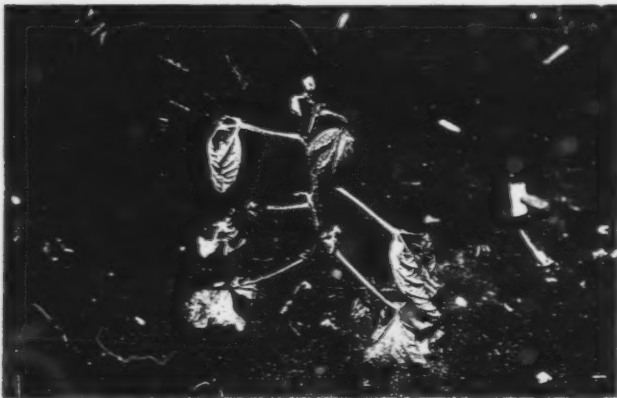


Figure 11. An isolated plant infected with Phytophthora root rot. The leaves remain attached when the plant dies.

Control of phytophthora root rot requires a combination of variety selection (see *Variety Selection*) and good soil management practices. Soybean varieties with resistance or tolerance to phytophthora are listed in OMAF Publication 296, *Field Crop Recommendations* and the *Ontario Soybean Variety Trials Report*. Any soil management practice that reduces soil compaction or waterlogging will lessen the severity of the disease. This includes plowing in crop residues and avoiding tillage when the soil is wet. Crop rotation will reduce but not eliminate the disease.

STEM DISEASES

White Mold (Sclerotinia stem rot)

White mold may cause damage to soybeans in August when weather conditions are cool and wet. Stems, pods and leaves infected with white mold are pale brown and water-soaked in appearance. Frequently, a white, cotton-like growth and small dark bodies (sclerotia) can be seen on or within the stems of diseased plants (Figure 12). These sclerotia may survive for many years in the soil. During the summer, this disease arises from airborne spores produced on the sclerotia.

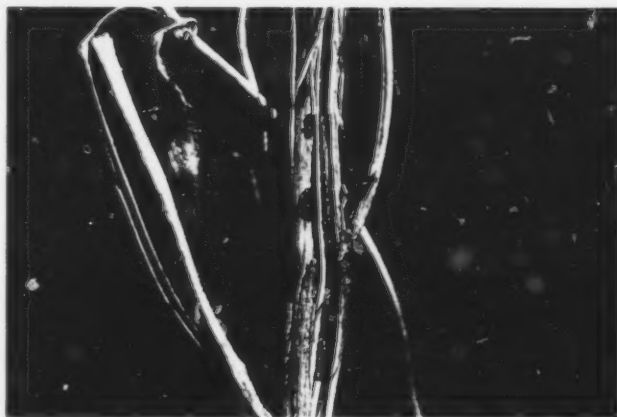


Figure 12. White mold sclerotia inside the stem of a diseased plant.

Crop rotation may be useful for disease control in areas where white mold is not common. White mold is more likely to occur where soybeans follow white beans, sunflowers or canola in which white mold was present in previous years. Avoid this crop sequence. In areas where white mold is common, the disease may appear despite crop rotation because of windblown spores from other fields.

Some differences in disease severity in varieties have been noted. No resistant varieties have been identified but field observations indicate that early varieties in an area are less prone to infection than later varieties. Similarly, varieties with greater lodging resistance tend to be less affected by white mold. For soybean fields with a history of severe white mold infection, producers should consider planting varieties which require 200-300 fewer heat units than normally available and which possess superior resistance to lodging.

Stem Canker

Stem canker can kill plant parts or entire plants during the period from pod-filling to maturity. Symptoms include a large, reddish-brown dead area on the main stem extending into the branches. Frequently the branches break off and pods fail to form at the infected nodes.

No resistant varieties have been found but some differ in tolerance to the disease. Use high quality seed and a recom-

mended seed treatment. Planting in narrow rows will generally reduce the amount of branch breakage.

Brown Stem Rot

Brown stem rot can kill plants during the period of pod-filling to maturity. Infected plants may be detected by splitting the lower stem. The center of the stem will be brown, especially at the nodes (Figures 13 and 14). Growing soybeans no more than one year in three, in rotation with non-legume crops, is the best means of control.

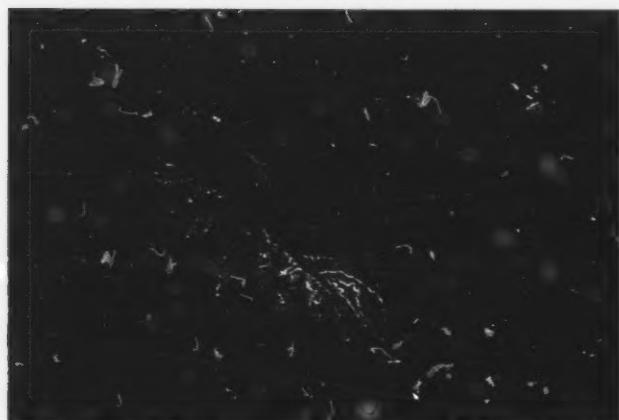


Figure 13. The foliar symptoms of brown stem rot of a diseased plant.

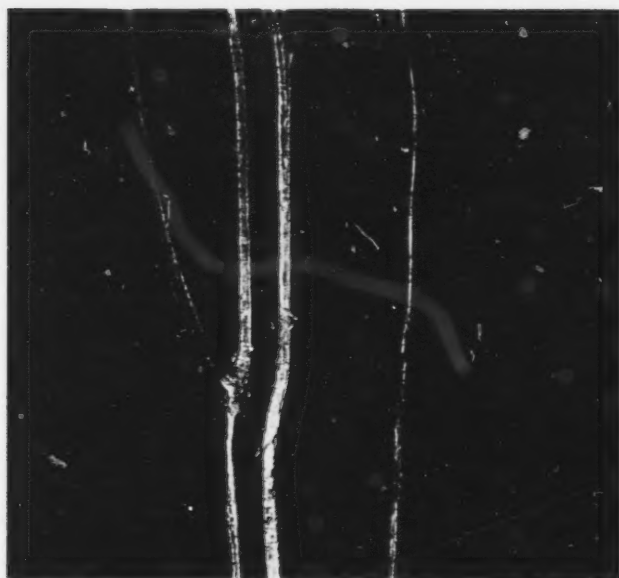


Figure 14. The stem of a plant infected with brown stem rot on the right and a healthy stem on the left.

FOLIAR DISEASES

Powdery Mildew

Powdery mildew develops on the leaves usually in August and September as a white powdery growth on the upper surface of the leaf (Figure 15). The seeds do not become infected. Yield losses usually occur only when outbreaks of powdery mildew begin in July, and continue until maturity. Cool

cloudy weather favors the disease. Resistant varieties are listed in OMAF Publication 296, *Field Crop Recommendations* and the *Ontario Soybean Variety Test Report*.

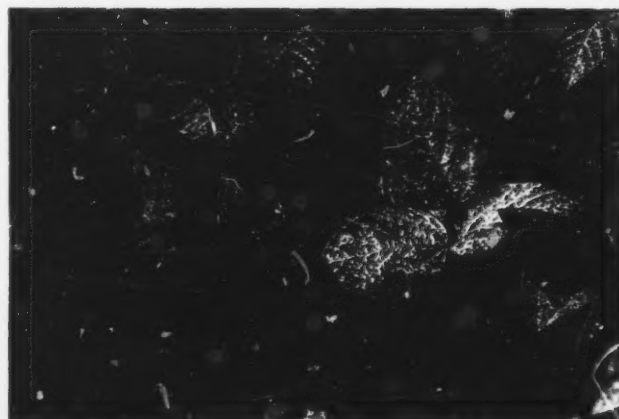


Figure 15. Powdery mildew on the upper surface of the leaves.

Downy Mildew

Downy mildew initially appears on the leaves as yellow spots which turn brown in August and September. In moist weather lesions show a pale blue to gray, cottony growth on the underside of the leaf (Figure 16). Severely affected leaves may drop prematurely. Whitish fungal growth may cover the seeds, even when the pods appear healthy. Varieties differ in susceptibility; the variety Evans is highly susceptible, but Maple Arrow has considerable resistance. Rotate soybeans with other crops or plow under soybean residue if soybeans are grown for more than one year.



Figure 16. Early infection of downy mildew appears as small, yellow spots on the leaves.

Bacterial Blight

Bacterial blight causes small (.3 cm), irregular brown dead spots on the leaves (Figure 17). Leaves may become torn and ragged as the dead areas fall out. This disease is very common during periods of cool, wet weather. With high summer temperatures, plants tend to grow out of it. There is no control.

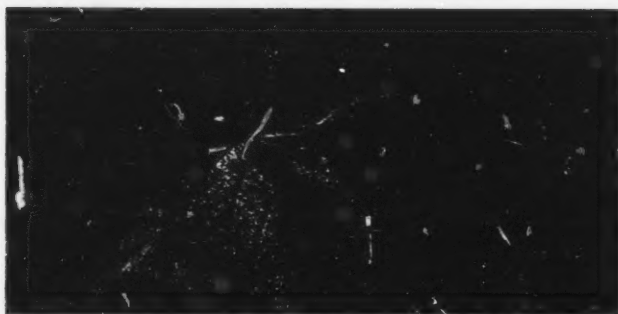


Figure 17. Leaves showing symptoms of bacterial blight.

Pod and Stem Blight (Phomopsis seed mold)

Pod and stem blight develops in the fall when weather conditions are warm and wet. Fine cracks develop on the seed coat of infected seed near the hilum. A white or grey mold may be visible on the seed surface (Figure 18). The yield, grade, viability and vigor of the seed may be reduced.

Whenever possible, grow full-season varieties. Varieties that are short-season for an area tend to mature earlier when conditions are warmer and more favorable for seed mold.

Germination and emergence of moderately infected seed can usually be increased by seed treatment. Damaged seed with visible fungal growth often fails to germinate, even when treated. Rotating soybeans with other crops and plowing under soybean residues will help to reduce disease severity.

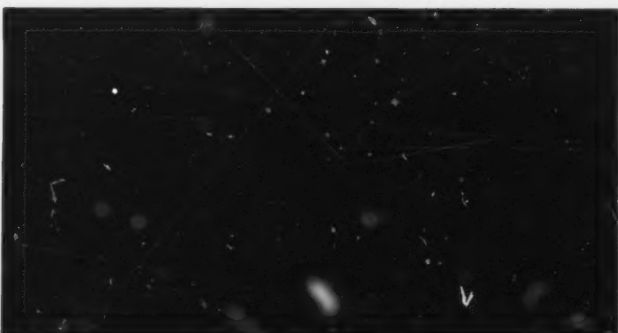


Figure 18. Seed encrusted with mycelium.

Cercospora Leaf Spot and Purple Stain of Seed

Cercospora has been observed in southwestern Ontario as a late-season leaf spot and a purple stain of the seed (Figure 19). This disease is of minor economic importance in Ontario. Control measures include using clean seed, a recommended seed treatment and crop rotation.

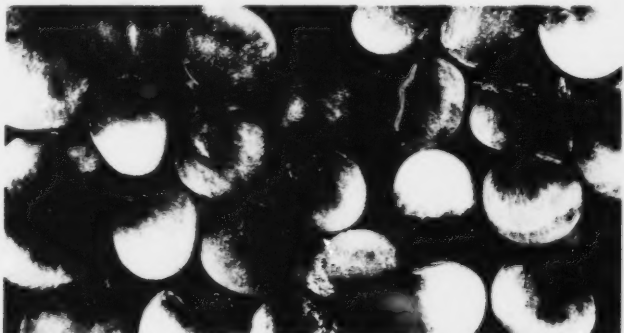


Figure 19. Purple stained seed caused by Cercospora leaf spot.

Other Diseases

A number of other diseases occur sporadically in Ontario. These include: soybean mosaic virus (Figure 20), bud blight, bacterial pustule, alternaria leaf spot, anthracnose, and charcoal rot. Detailed descriptions of these diseases can be found in other sources of information listed at the back of this publication.

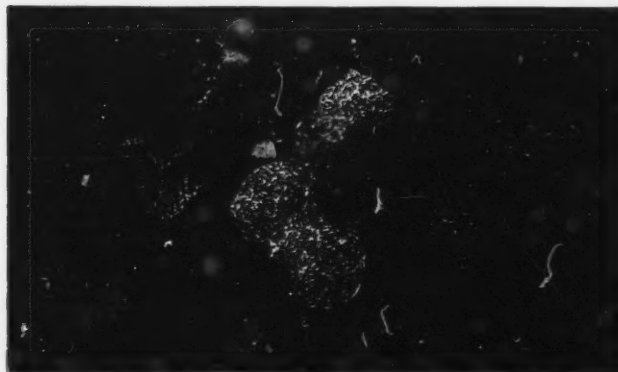


Figure 20. Soybean mosaic virus appears as a distortion of the leaves.

INSECTS AND MITES

Soybeans generally are not seriously damaged by insect pests in Ontario. Seed maggots (Figure 21) and wireworms may damage the emerging crop by feeding on the seed and seedlings. Apply seed treatments containing an insecticide.



Figure 21. Seedcorn maggot feeding damage.



Figure 22. Green clover worms (loopers).

In some years the green cloverworm (loopers), feed on the soybean foliage during mid-season and causes holes in the leaves (Figure 22). Shake the worms from the plants onto paper and count them. If more than 15 to 20 worms are found per metre of row, spray according to recommendations found in OMAF Publication 296, *Field Crop Recommendations*.

Grasshoppers can be a problem in some years. They begin feeding on the outer rows and work toward the center of the field. In many cases they can be controlled by spraying the outer rows during the initial feeding according to recommendations.

Mites are occasional pests of soybeans. The adults are tiny, rounded, eight-legged and usually red. Both the adults and the immature ones feed on plant juices from the undersides of leaves (Figure 23). Their feeding causes yellowing, curling and bronzing. A close examination will show fine webbing on the lower surface of the leaves and the tiny mites with two dark spots (Figure 24).

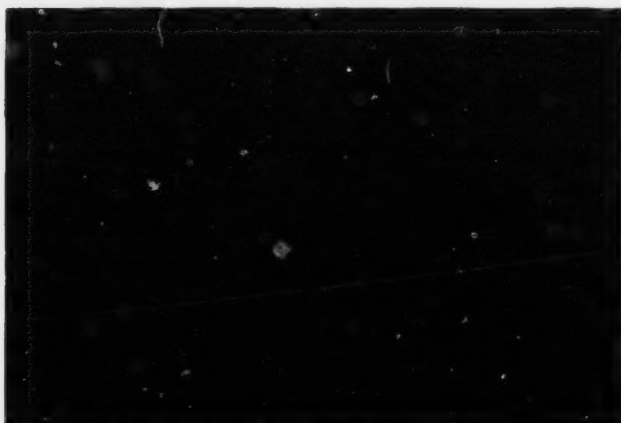


Figure 23. Spider mite feeding damage on soybean leaves.

There are many generations a year. As grain and other crops mature the mites can move into soybean fields. Four or more mites per leaf or one severely damaged leaf per plant warrant chemical control. If rain is forecast, spraying should be delayed because the rain will usually reduce the number of mites to insignificant levels.

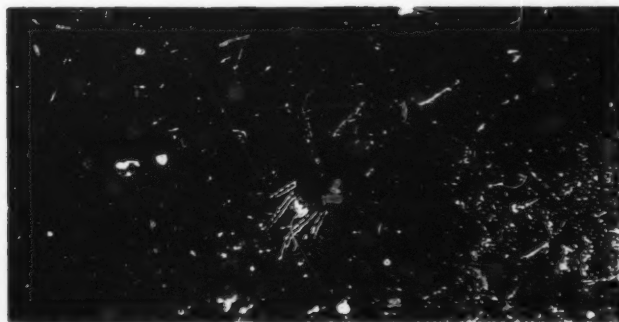


Figure 24. A magnified view of a spider mite.

For chemical control, see OMAF Publication 296, *Field Crop Recommendations*.

Soybean Cyst Nematode

This potentially serious pest of soybeans was identified in two fields in Kent County in 1987. Nematodes damage the root system and prevent the uptake of water and nutrients. These microscopic worm-like organisms cause some yellowing of leaves and stunting of plants, particularly on the lighter soils during periods of moisture stress (Figure 25). Damage is usually in a circular pattern ranging from a few meters to over 50 meters in diameter. Roots of infected plants are usually dark and have few nodules. Often small, white to brown cysts are visible on the roots (Figure 26). If you suspect soybean cyst nematode damage consult your local OMAF Soils and Crops Specialist.

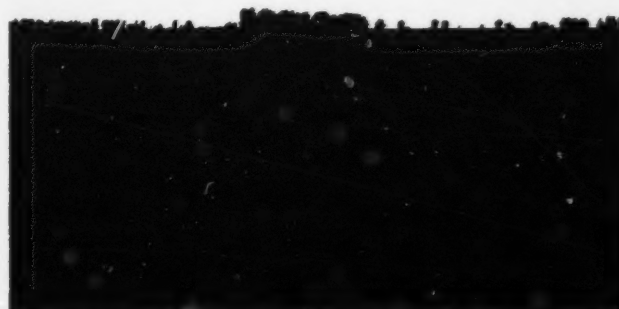


Figure 25. Field symptoms of soybean cyst nematode.



Figure 26. The roots of a soybean plant infected with soybean cyst nematode. Note the tiny, white cysts on the secondary roots. The larger, darker "cysts" are nitrogen fixing nodules.

OTHER PROBLEMS

Frost

Frost damage can occur in Ontario as a result of early planting and a late spring frost. Damage is usually limited to the upper parts of a plant and new growth starts from one of the undamaged buds lower on the plant (Figure 27). If the entire plant is dead then replanting is necessary.

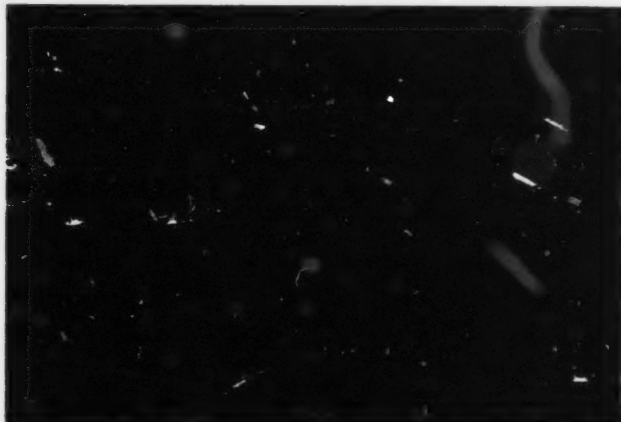


Figure 27. Frost damage; replanting is not necessary as only the upper leaves are damaged.

Groundhogs

Groundhog damage is sometimes mistaken for herbicide or insect damage. The feeding damage is usually close to fence rows or stone piles where the groundhogs live. A mature groundhog may eat up to one hectare of seedlings. If the plants are eaten to below the cotyledons, replanting is necessary (Figure 28).

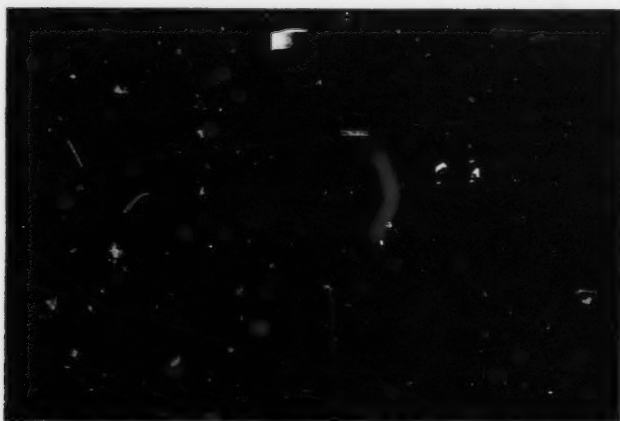


Figure 28. Groundhog damage.

Hail

Hail can occur anytime during the growing season in Ontario. Early season hail can cut the plants off anywhere above the soil surface. If the remaining portion of the plants has living buds then replanting is not usually necessary (Figure 29). Hail damage during the summer appears as torn leaves and distinct bruising on the stems and branches (Figure 30).



Figure 29. Hail damage early after emergence.



Figure 30. Hail damage in June causing bruising of the stem and branches.

Lightning

Lightning kills soybeans in circular areas in a field up to 15 m in diameter (Figure 31). This injury is often mistaken for other problems such as root rots, or herbicide damage. It can be distinguished from other problems by a sudden death of both soybeans and weeds in the area and the fact that this area does not expand in size.

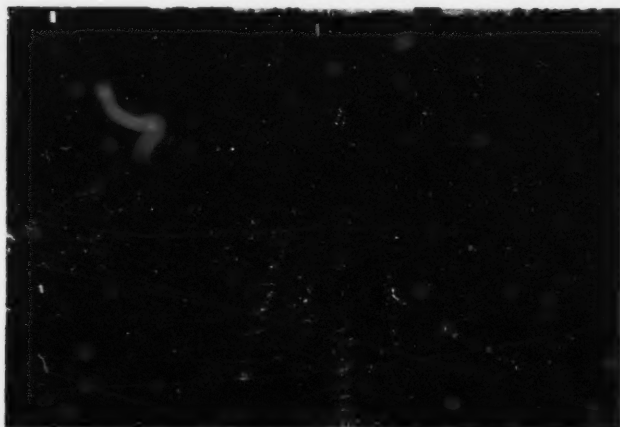


Figure 31. Lightning damage; all plants were killed in a circular pattern around the lightning strike.

Sunburn

Sunburn damage first appears as small, interveinal brick-red spots on both upper and lower leaf surfaces. If the damage is severe the discoloration may spread along and over the veins (Figure 32). As damaged tissue dies, fungi may colonize the area.

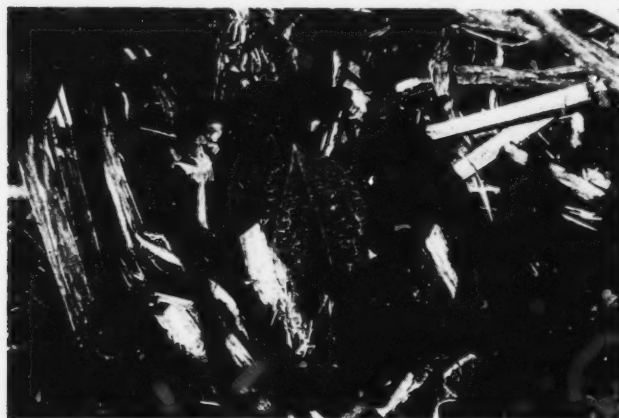


Figure 32. Sunburn on the upper leaf surfaces.

HARVESTING AND STORAGE

Harvesting

Soybeans are direct combined, preferably with a combine equipped with a floating flexible cutterbar and automatic header control. Soybeans can be harvested at moisture levels below 20% but they must be stored at 14% moisture or lower. Harvest losses and damage are high when soybeans are harvested below 12% moisture. Four beans per 900 cm² (per square ft) represent a 70 kg/ha (1 bu/ac) loss.

Use of a floating cutterbar allows cutting closer to ground level (Figures 33 and 34). The reel speed should be 25% faster than ground speed. Losses can be minimized if a ground speed of 4 to 5 km/h (2.4 to 3 mph) is maintained. The fan should be adjusted to provide maximum air without blowing soybeans into the return elevator or out the back. The chaffer is adjusted to allow the fan to separate pods and stalks from the soybeans and the sieve to allow only soybeans through. Adjust these settings as the conditions of weather and soybeans change.

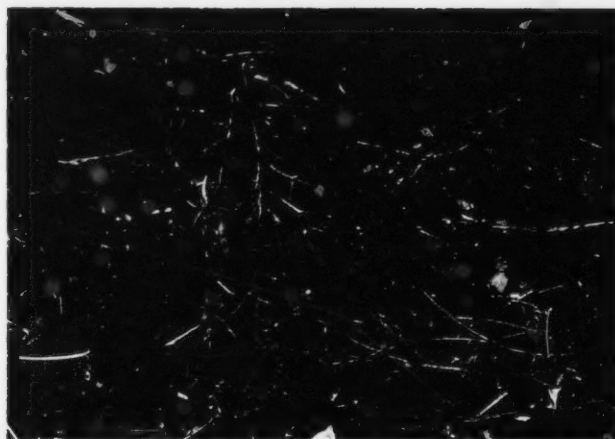


Figure 33. Increased harvest losses due to a high riding cutterbar.



Figure 34. The same field harvested with a floating cutterbar greatly reduced losses.

When soybeans are stored in large quantities for long periods of time or during warm weather, provision must be made for aeration to prevent mold and heating, even when the beans are low in moisture. If soybeans are not aerated, they can turn rancid and become discolored, resulting in a lower grade. For aeration to work well, the beans should be free of plant debris and cracked beans should be at a minimum.

STORAGE AND DRYING

Safe moisture levels for storage depend on air temperature, volume stored and whether the beans are to be used for processing, feeding or as seed (Table 4).

Table 4. Moisture Guidelines for Safe Storage of Soybeans

Moisture Content (%)	Effect on Bean Quality
11	Can safely be stored for long periods of time, but there is a risk of mechanical damage to the seed.
12 - 13	Maintain commercial grade for two to three years, but germination begins to decrease in the first year.
13 - 14	Can be stored for a year, but germination starts to decline in the spring when temperatures rise.
14 - 15	Seed overwinters but will deteriorate in the spring.

The effect of seed moisture on storage is complicated by the fact that moisture migrates in the bin. During cool periods, air in the bin adjacent to the outer walls sinks as it cools and warmer air rises through the center of the bin carrying moisture with it. The net effect is that the center top of a bin or peak in a pile accumulates moisture (Figure 35). Farm bins filled with beans at 12 to 13% moisture may reach moisture contents of 16 to 17% near the top center and bean quality will deteriorate.

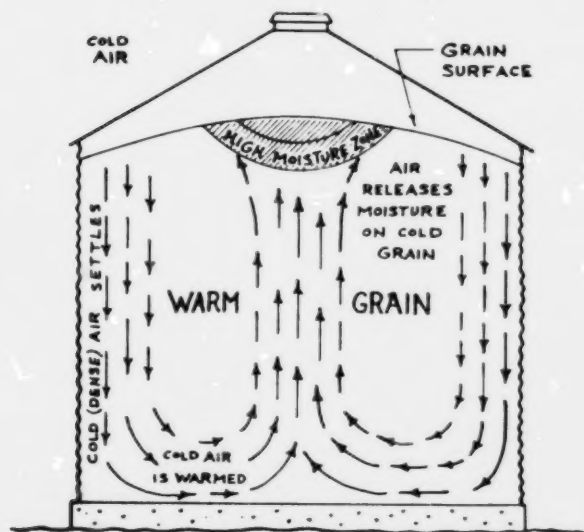


Figure 35. Moisture migration patterns in stored grain.

Soybeans can be dried with conventional grain driers but the percentage of cracked beans increases rapidly with high drying temperatures and air low in relative humidity. In conventional driers air temperature less than 38°C and relative humidities of 40 to 50% produce good quality beans.

The most economical way to dry soybeans for many growers is by drying in the storage bin. Bins equipped with full perforated floors are ideal but suitably designed duct systems also work well. Unheated air can be used if it will remove enough water. Generally this means air temperatures are above 15°C and relative humidities are below 70%. Heat can be added to the airflow by resistance heaters, heat lamps, or heat from the motor driving the fan. Ideally, an aeration system should move air down through the grain so the dry, outside air passes over the upper, more moist grain first. However, airflow up through the soybeans can also be used.

FEEDING SOYBEANS

Soybeans have traditionally been grown as a cash crop but serious consideration should be given to on-farm feeding of whole soybeans. Whole soybeans contain approximately 40% protein and 20% oil on a dry basis, compared with soybean oil meal at 44 or 49% protein and 0.5% oil. The oil in whole soybeans provides a concentrated energy source in the live-stock ration. However, this energy source is not utilized fully by livestock.

Soybeans must be heat-treated or roasted before being fed to swine and poultry. The heating process destroys growth-inhibiting factors which exist in large amounts in raw soy-

beans and interfere with the digestion of protein in young single-stomached animals.

Feeding trials have indicated that swine and poultry will gain at a similar rate when either cooked whole soybeans or soybean oil meal are included in the ration as the protein source.

When heat-treated soybeans are fed to pigs, there is a tendency for carcasses to have slightly softer fat. This problem could be corrected by replacing heat-treated soybeans with soybean oil meal toward the end of the finishing period.

Cattle and sheep may be fed raw soybeans with good results. When mixed in proportionate amounts with other grains, soybeans may be successfully ground or crushed to make a palatable feed to supply the protein requirements in the ration. Ground soybeans or mixtures containing raw soybeans should not be stored for more than a week in warm weather, as oil in ground beans becomes rancid.

Soybeans should not be combined in a ration that already contains urea because of a urease enzyme present in raw soybeans which, when combined with urea, reduces the value of the urea as a protein food.

Economics must be considered in deciding whether to feed whole soybeans on the farm or to sell them for processing and buy soybean oil meal. The cost of buying soybean oil meal, the selling price of soybeans (including moisture and grade), as well as the cost of heat processing for single-stomached animals, should be considered when determining the economics of feeding soybeans.

MARKETING

Approximately 24,000 growers in Ontario market their crop through 300 local dealers. One-third of the soybeans are marketed by growers during or shortly after harvest in October, November and December. Once off the farm, soybeans come under the legislation of the Farm Products Marketing Act. Growers established a marketing scheme in 1949 and, in turn, established the Ontario Soya-Bean Growers' Marketing Board to administer the Ontario Soya-Bean Growers' Marketing Plan. It is through this plan that present marketing procedures were developed. Although the Marketing Board does not engage in the actual handling or marketing of soybeans, the soybean crop is sold under terms and conditions negotiated annually between the Marketing Board and dealers and processors.

Under the Ontario Soya-Bean Growers' Marketing Plan, the negotiated agreement for marketing each crop of Ontario soybeans deals basically with price, terms and conditions of sale. The minimum price paid for Ontario soybeans is equivalent to the cost of imported beans of equal quality in Canadian funds. In the event that processors are unable to import soybeans, the minimum price is determined by market prices for soybean products.

By agreement, the conditions of sale include payment by dealers to the growers either by cash on delivery or by deferred pricing contract. In addition, the dealer handling and drying charges are negotiated annually by the board, dealers and crushers. Any dispute involving moisture content and grades between the grower and the dealer are referred to the Canadian Grain Commission for arbitration and settlement.

Complete details of the current agreement for marketing soybeans may be obtained from the Ontario Soya-Bean Growers' Marketing Board, Box 1199, Chatham, Ontario N7M 5L8.

REFERENCES

Publications

Publication 296, *Field Crop Recommendations*, OMAF

Publication 75, *Guide to Weed Control*, OMAF

Publication 229, *Insects in Farm-Stored Grain*, OMAF

Ontario Oil and Protein Seed Crop Committee, *Ontario Soybean Variety Trials Report*

Factsheets

Agdex

Number

Title

100/531	<i>Manganese in Soybean and Small Grain Production</i>
100/536	<i>Tillage Practices for Residue Management and Erosion Control</i>
100/708	<i>Energy Input and Output of Grain, Corn and Soybean Production</i>
110/717	<i>Grain Aeration</i>
111/31	<i>Heat Units for Corn in Southern Ontario</i>
141/840	<i>Pricing and Marketing Soybeans</i>
142/622	<i>White Bean Insects</i>

Additional References

Modern Soybean Production, 2nd ed. Scott, W.O. and S.R. Aldrich, S. and A. Publications, P.O. Box 2660, Station A, Champaign, Illinois 61820, 1983.

Diseases of Field Crops in Canada, Martens, J.W., W.L. Seaman and T.G. Atkinson eds., Canadian Phytopathological Society, P.O. Box 437, Harrow, Ontario N0R 1G0, 1984.

Compendium of Soybean Diseases, 2nd ed. Sinclair, J.B. ed. American Phytopathological Society, 3340 Pilot Knob Road, St. Paul, Minnesota 55121, 1982.

Soybeans: Improvement, Production and Uses, 2nd ed. Wilcox, J.R. ed. American Society of Agronomy, 667 S. Segoe Road, Madison, Wisconsin 53711, 1987.